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for Plutonium Oxide Storage

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A Comparison of the Design of Russian and US Containers for Plutonium Oxide Storage.

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Introduction

The safe storage of plutonium in the form of plutonium oxide (PuO_2) is a major concern in countries with significant plutonium inventories. The goal is to stabilize and package oxide in such a way that the possibility of leaks and failures are unlikely.

Currently in Russia, PuO_2 is stored ¹ at the Mining and Chemical Combine (MCC, Zheleznogorsk) and at the Siberian Chemical Combine (SCC, former Tomsk-7). (Plutonium metal is stored at PA "Mayak" and is not addressed here). Current storage containers for Russian PuO_2 do not meet modern safety requirements. Further, every three years the gaskets have to be replaced. The containers can become over pressurized due to radiation processes and this results in possible container failures ¹.

In the US, PuO_2 is present at several Department of Energy (DOE) sites ². US reports of long time storage of PuO_2 show a few cases of storage container failures ² among thousand of intact cases. Major causes of malfunction are metal oxidation in non-airtight packages and gas pressurization from inadequately stabilized oxide. Because of these failures the US DOE adopted a standard ³ for stabilization, packaging and storage of plutonium-bearing material that addresses these vulnerabilities.

Research programs both in Russia ⁴ and the US ⁵ continue to evaluate metal corrosion, gas generation ^{e.g. 6} and interaction of PuO_2 with residual water ^{e.g. 7} that may contribute to package failure.

Criteria

The stabilization requirements of the DOE standard are intended to accomplish the following objectives:

- Eliminate reactive materials such as sub-stoichiometric plutonium oxides;
- Eliminate organic materials;
- Reduce water content to less than 0.5wt % and reduce equivalent quantities of species that might produce water;
- Minimize potential for readsorption of water above 0.5 wt% threshold; and
- Stabilize any other potential gas-producing constituents.

The standard also addresses the perceived benefit of calcining PuO_2 to reduce the respirable fraction of the powder.

Although there are Russian regulations regarding packaging⁸ of PuO_2 there are no analogous regulations to the US 3013 standard³ regarding the stabilization of PuO_2 powder prior to storage.

Russian Storage Container Design⁸⁻¹¹

Figure 1. shows the inner container and convenience can to store oxide¹⁰ that is being developed at the A.A. Bochvar All Russia Research Institute of Inorganic Materials (VNIINM), Moscow. The inner container is sealed with a bolt and gasket and is configured to hold the inner container to prevent motion during handling. In some variants of design, the outer container is welded rather than bolted.



Figure 1. Photograph of inner Russian container for PuO_2 storage¹⁰ with convenience can.

The system is designed to hold about 4 kg of PuO_2 . The dimensions of the inner container are ~10" tall with a diameter of ~10". The welded or bolted cover contains an O-ring compression in the top center that allows for gas to be sampled or vented through a built-in filter. The exterior of the can is electropolished. Concern centers around the ability to decontaminate the outer surface of the inner container lid. This may¹¹ be decontaminated electrolytically or by the use of polymeric coatings.

Figure 2 shows a schematic of the Russian design⁸ with the inner and outer containers and a convenience can. There is an alternate version with the convenience can having a wider mouth.

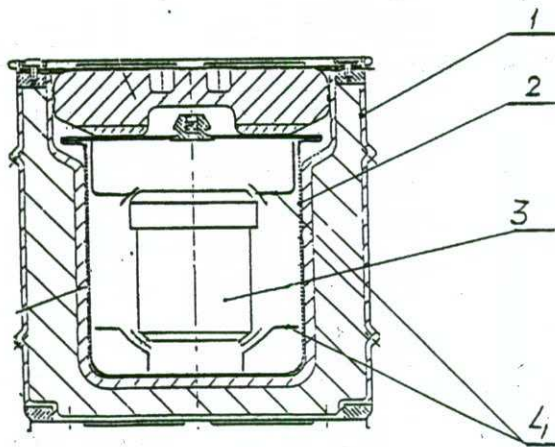


Figure 2. Schematic of Russian container design ⁸ showing:
 1 – outer container, 2 – inner container, 3 – convenience can, 4 – design elements.

US Storage Container Design. ¹²

Figure 3. shows the British Nuclear Fuels Ltd. (BNFL) Boundary (Outer) Container and Fig. 4. a schematic of the US designed system.



Figure 3. British Nuclear Fuels Limited (BNFL) Boundary Container (Outer Container).

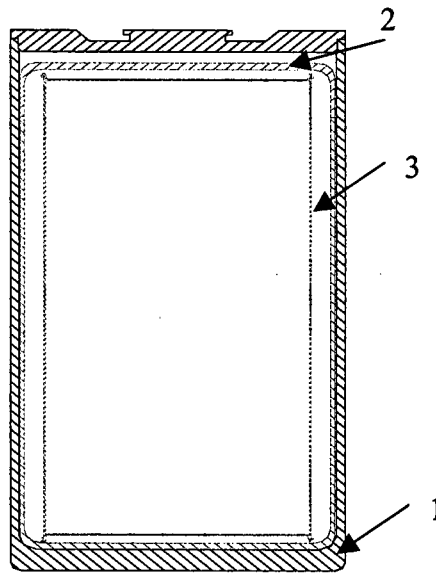


Figure 4. Schematic of US can design showing:
1 – outer container, 2 – inner container, 3 – convenience can.

The schematic shows the outer container (the BNFL Boundary Container) with the lifting fixture on the top. Both outer and inner containers are made of welded stainless steel and are designed to the 3013 standard. The dimensions of the whole system are ~ 10" tall with a diameter of ~ 5". The inner convenience can is not required by the 3013 standard but has been made of tin plated rolled steel as in a food pack can. After the oxide is placed in the convenience can, the can is placed in the inner container that is welded shut. Its outer surface is decontaminated before being placed in the outer container that is also welded¹³ shut and can then be placed in a standard shipping container.

The specifications³ for storage for PuO_2 require the oxide to be thermally stabilized in an oxidizing atmosphere for two hours at 950°C prior to storage. This ensures that the water content is less than 0.5 wt %, as required by the standard and accomplishes other safety related goals. The containers are designed to withstand pressures in excess of 700 psig – the theoretical maximum pressure that can be obtained under “worst case” conditions of 0.5 wt % moisture, 19W heat generation and 211°C .

Comparison

Both Russian and US systems hold about 4 kg of PuO_2 . The Russian containers are roughly twice as wide as the US design.

For primary containment, the Russian design uses bolts and gaskets whereas the US uses a hermetically sealed welded container¹³. One resulting concern of the Russian design is the alpha radiolytic degradation of gaskets and covers, made of rubber, polypropylene and fluoroplastics when in direct contact with plutonium.

The Russian system is designed to be attached directly with the plutonium handling line both for loading and unloading, while in the US system, the containers are inserted into the process line (glove box line).

In the US containers have to meet the 3013 standards whereas in Russia no formal equivalent to the 3013 standard exists.

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